

MIGRATION OF RESEARCH RESULTS INTO OPERATIONAL MONITORING SYSTEMS

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Sponsored by U.S. Department of Energy
Office of Nonproliferation Research and Engineering
Office of Defense Nuclear Nonproliferation
National Nuclear Security Administration

Contract No. DE-AC04-94AL85000

ABSTRACT

For the Department of Energy (DOE) Knowledge Base to support activities for monitoring nuclear explosions consistent with eventual verification activities under the Comprehensive Nuclear-Test-Ban Treaty (CTBT), a process is defined to ensure the integrity and utility of research results during the migration into information products for use in operational monitoring systems.

The process of validating, verifying, and managing the information products ensures deliveries of high-quality Knowledge Base releases to the United States National Data Center (USNDC). These activities are critical to the successful integration of scientific research to support operational monitoring systems at the USNDC. A by-product of this process is that data sets, or components of information products, that have undergone the validation and verification process may be distributed as operational calibration products to the International Data Centre. All contributors to information products, whether DOE-funded or not, will benefit from transparency of the integration process to effect successful participation in the process.

As an information product passes through the steps necessary to become part of a delivery to the USNDC, domain experts, including the end-users, will provide *validation* -- a determination of relevance and scientific quality. The integration process continues with *verification* -- an assessment of completeness and correctness, provided by the Knowledge Base integrator, the information product coordinator, and the contributing organization. The information products and their constituent data sets are systematically tracked through the integration portion of their life cycle (Moore, et al, 2000; Carr et al, 2000).

Finally, the proposed delivery of the Knowledge Base and its constituent information products is reviewed by an Integration Board. The integration process is presented in this paper, with details described in Moore et al., (2000).

Key Words: DOE Knowledge Base, information product, integration, verification, validation

OBJECTIVE

A well-defined process ensures the integrity and utility of research results during the migration into information products for use in the DOE Knowledge Base to support activities for monitoring nuclear explosions consistent with eventual verification activities under the Comprehensive Nuclear-Test-Ban Treaty (CTBT). The process of validating, verifying, and managing the information products ensures high-quality deliveries to the United States National Data Center (USNDC).

RESEARCH ACCOMPLISHMENTS

The process for migrating research results into information products for use in the DOE Knowledge Base has been defined and implemented. This process and its implementation ensure that the delivery of a DOE Knowledge Base comprises verified, validated, and well-managed information products. If any process is to retain its effectiveness, it must be refined over the course of its use; thus, this process is also undergoing refinement. This paper describes the integration process as documented in Moore et al. (2000) with refinements developed during its most recent

implementation. This paper serves the purpose of offering transparency of the integration process to facilitate effective participation in the process by all contributors to information products.

Motivation and benefits of the integration process

For the DOE Knowledge Base to be useful as a tool for improving U.S. monitoring capabilities, the contents of the Knowledge Base must be subjected to a well-defined set of procedures to ensure integrity and relevance. The integration process addresses the following issues:

1. What do end-users want and need?
2. How do researchers collaborate to address those needs?
3. How is research integrated into a useful and reliable product?

These questions drove the development of the integration process and are answered explicitly at the end of this paper after the process is described.

In addition to ensuring integrity, relevance, and usefulness of the information products, the integration process provides additional benefits:

- Evidence that the process was followed. All steps in the process are logged.
- Direction for interactions. Procedural guidance provided by the process ensures effective, purposeful interactions.
- Programmatic benefits. The procedure provides a basis for scheduling and offers periodic status reports.

Description of the process

Figure 1 summarizes the state changes for information products (IP).

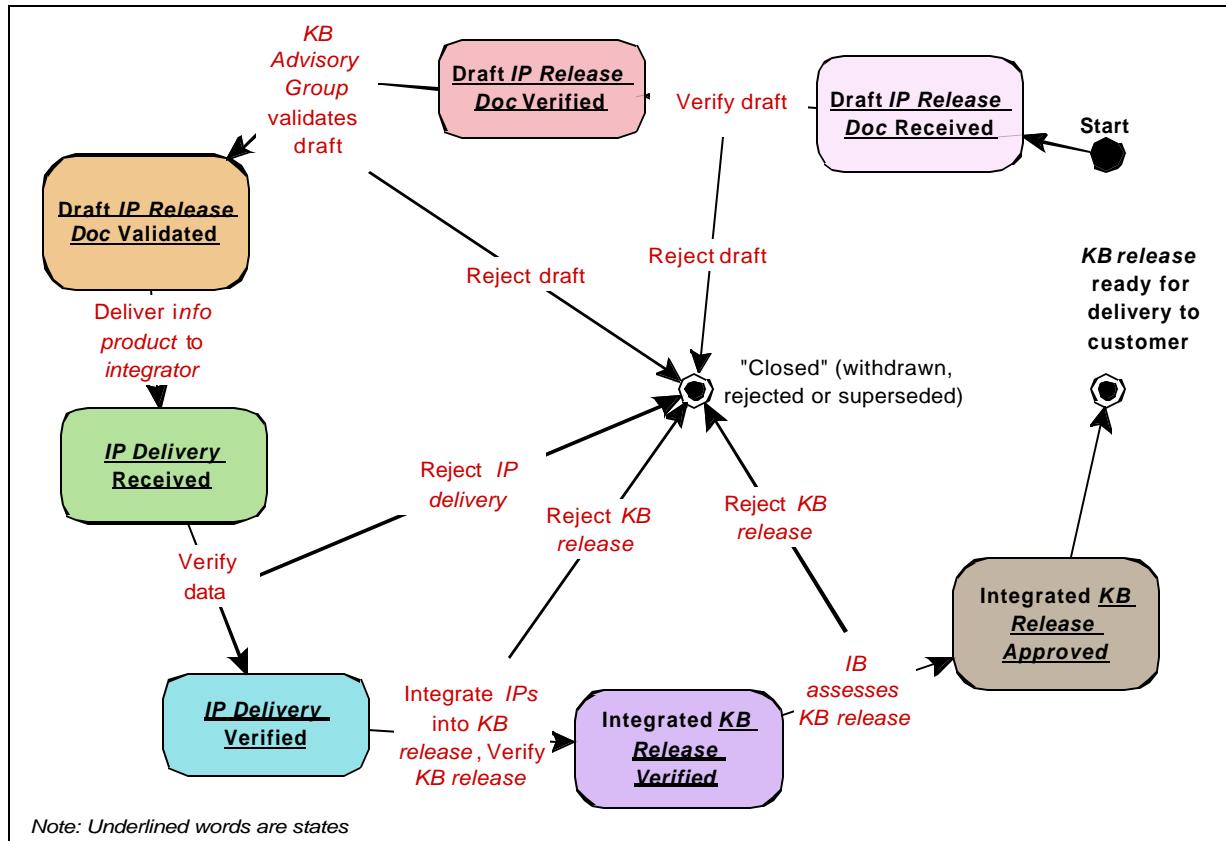


Fig. 1. State transition diagram for Information Product integration into the Knowledge Base.

The following nomenclature is used for the integration process and Knowledge Base releases. An *information product* comprises

- one or more conceptually related data sets
- metadata corresponding to each data set
- an information product release document (described in state 1 below)
- any associated models, interface tools, or visualization tools.

A *data set* is a collection of data usually all of the same kind; examples include event data, contextual data, or parametric grid data. *Metadata* describes the content, source, quality and condition of a data set.

The integration process defines *states* through which an information product passes as it migrates from the research environment into the Knowledge Base. Though the integration process is a joint effort, Sandia National Laboratories (SNL) holds the primary responsibility for integrating information products into the Knowledge Base, so the states in the diagram are defined relative to SNL's role. As the Knowledge Base integrator, SNL systematically tracks each of the states for each of the information products offered for inclusion in the Knowledge Base.

1. The initial state of the process is Draft Information Product (IP) Release Document Received. A *release document* is developed by a contributor (a research organization, typically) and contains at a minimum:
 - information product identification
 - content description
 - changes since prior versions
 - installation instructions.

When the draft version of the release document is received, it indicates that the contributor intends to submit an information product for inclusion in the Knowledge Base, so the Knowledge Base integrator begins tracking that proposed information product. The Knowledge Base integrator also identifies two points of contact for this specific information product:

- An *information product coordinator* who represents the contributing organization.
- An *information product integrator* (representing the Knowledge Base integrator organization) who will work with this particular information product. This paper will continue to refer to the Knowledge Base integrator for clarity in process description, but it is a specific person, the information product integrator, who performs the integration and tracking for a particular information product.

The Knowledge Base integrator reviews the draft release document for completeness. If unsatisfactory, the draft release document is returned to the contributor with feedback. If the draft release document is found to be satisfactory, the information product is promoted to the next state.

2. In this state, Draft Information Product Document Verified, the proposed information product represented by the draft release document is subjected to technical review via the Knowledge Base Advisory Group for that information product. The Advisory Group comprises
 - domain experts from peer organizations and
 - one or more representatives from the end-user organization.

The Advisory Group provides *validation*, a determination of relevance and scientific quality, of the information product proposed for inclusion in the Knowledge Base. The assessment is based on whether or not the proposed information product supports the defined monitoring goals. Written assessment and recommendations are provided to the contributor and to the Knowledge Base integrator.

If the Advisory Group deems the information product (represented by its draft release document) unsuitable, then the draft release document is returned to the contributor with feedback. If satisfactory, the information product is promoted to the next state.

3. At this point, Draft Information Product Release Document Validated, the contributor prepares the delivery of the information product by
 - finalizing the release document,
 - synthesizing the research data,
 - completing the associated metadata, and

- completing associated interface tools.

Meanwhile, the Knowledge Base integrator (SNL) uses the validated draft release document as a basis for integrating the information product into the Knowledge Base. For example, the release document provides information about quantity and format of the forthcoming data, which helps with system configuration, both in the integration test bed and at the end-user site. Also, the release document provides information about testing and verifying the forthcoming information product, which aids in the verification process. It provides information about associated process tools and interface tools, which helps coordinate tool development and testing.

4. The integration process continues when the contributor delivers the comprehensive information product for integration; SNL logs this state as Information Product Delivery Received.

The information product is considered received when all data sets comprising the information product have been received, all metadata received, the final release document received, and any interface tools for process or visualization have been received.

The Knowledge Base integrator performs extensive verification of the information product for completeness, consistency, and correctness, based on the preparation using the release document. The integrator tracks each data set contained in the information product and its associated metadata for both receipt and verification. The integrator may return the information product to the contributor with feedback if the information product or one or more of its data sets are found to be unacceptable, incomplete, or missing. If acceptable, the information product is promoted to the next state.

5. This state, Information Product Delivery Verified, indicates the information product is ready to be integrated into a Knowledge Base release.

At this point, several verified information products are integrated into a potential Knowledge Base release. The combined release is verified at a system level, appropriate classification issues are addressed, and the Knowledge Base integrator develops a Knowledge Base release document. The Knowledge Base integrator synthesizes the following to complete the integration into the potential Knowledge Base release:

- the comprehensive potential release and its release document,
- information product release documents,
- Advisory Group recommendations, and
- tracking reports demonstrating the verification, validation, and management of the information products.

6. With verification activities completed, the state now becomes Integrated Knowledge Base Release Verified, which means the proposed Knowledge Base release and its supporting documentation are ready to be presented to the Integration Board for approval.

In addition to the potential release and its supporting documentation presented to the Integration Board, contributors are encouraged to present an overview of their respective information products during the Integration Board meeting.

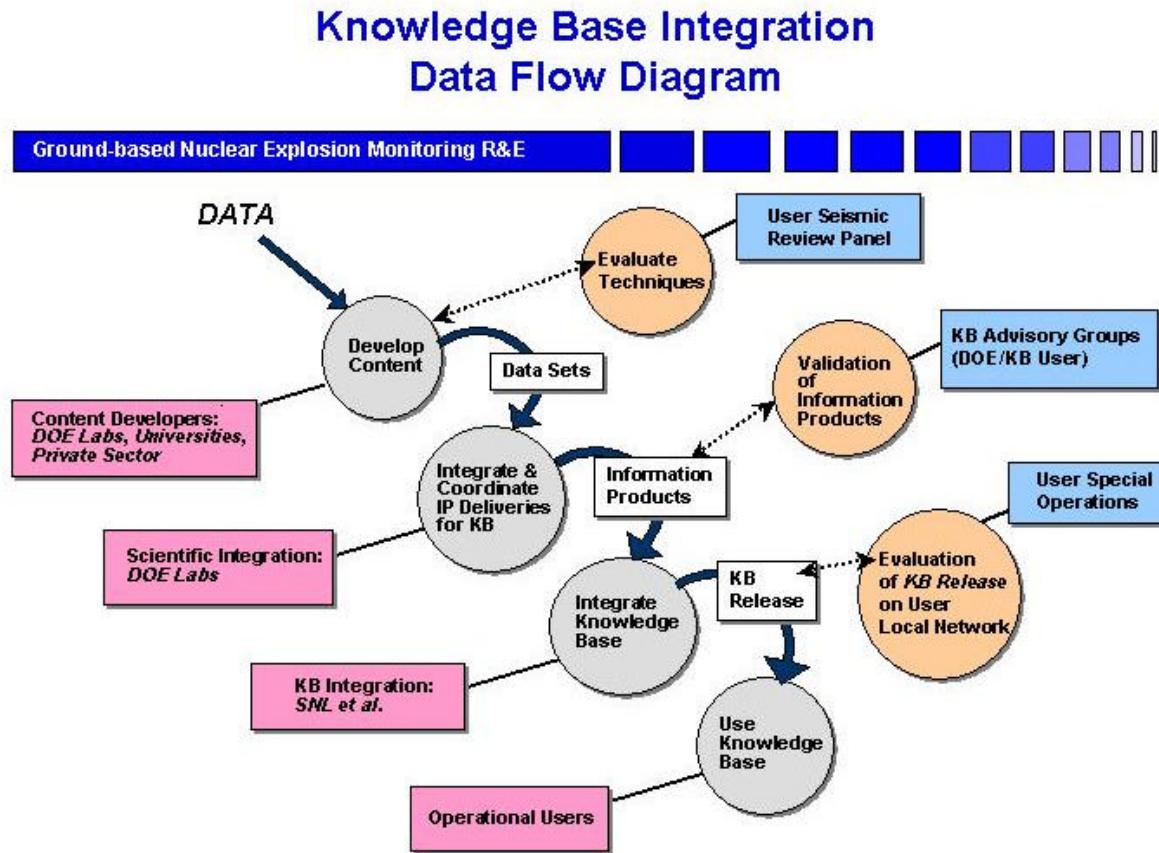
The purpose of the Integration Board is to provide high-level approval that the information products have been verified, validated, and properly integrated based on recommendations by the Knowledge Base Advisory Groups, which have accepted the information products after technical review. The Integration Board comprises, at a minimum, a program leader from each contributing organization, the DOE sponsor, and a technical representative from the end-users' site. Specifically, the purpose of the Integration Board is to

- review the contents of the potential Knowledge Base release
- be advised by the Knowledge Base Advisory Groups' reports
- be informed by the information product status reports from the tracking tool used in the integration process
- accept or deny all or part of the potential Knowledge Base release.

7. If the Integration Board approves the potential release, then the state becomes Integrated Knowledge Base Release Approved, and the approved Knowledge Base release is delivered to the USNDC. Integration of specific

information products into a Knowledge Base release does not guarantee acceptance by the USNDC, which exercises its own review process after receipt of a release.

This integration process can also be summarized in terms of data flow, as shown in Figure 2.



**Figure 2. Basic data flow for Knowledge Base Development and Integration
(shown relative to parallel user evaluation process).**

How the process addresses the original issues

The integration process was developed to address three issues mentioned early in this paper. Those issues are explicitly addressed here.

What do end-users want and need?

The integration process includes end-users early on with their participation in the Advisory Group review of the draft release document for validity or relevance of a proposed information product. The needs of end-users are addressed even earlier by the contributing organizations with their interactions with end-users. These interactions, while outside the scope of the integration process, form the basis for the research and any resulting information products. Further, the end-users are represented on the Integration Board to ensure their needs are met.

How do researchers collaborate to address those needs?

The integration process provides guidance in collaborating by establishing the roles of information product integrator and information product coordinator. These two roles must work closely together using a well-defined process to ensure successful integration of scientific research results into a useful information product. In addition, the integration process provides evidence, or documentation, of the collaborations to support the usefulness and reliability of the information products.

How is research integrated into a useful and reliable product?

One of the original and enduring requirements in developing a process to integrate research results into information products for use within the Knowledge Base is that the process may not prescribe the type or amount of data developed by the researchers. That is, the process must integrate a wide range of data types, data complexity, and data volume. The purpose for this requirement is to accommodate, not constrain, the researchers in their work so that the full utility of their research is maintained during its integration into the Knowledge Base.

CONCLUSIONS AND RECOMMENDATIONS

The process of validating, verifying, and managing the information products is critical to the successful integration of scientific research to support operational monitoring systems at the USNDC. We have defined and implemented a successful process to date.

Continued success of the integration process relies on the following:

- The integration process is rigorous and well-defined.
- All contributors, whether DOE-funded or not, are knowledgeable about the process.
- The process continues to be refined as USNDC requirements emerge and as various types of research evolve.
- We get and incorporate feedback from the end-users concerning the usefulness of the format and functionality.
- We get and incorporate feedback from the end-users regarding the validity of the content and functionality.

Near-term work on the integration process includes the following:

- Evolution of process tools. The tracking tool will be modified to incorporate refinements to the process and enhanced to generate various types of reports such as tracking by information product or tracking by contributor.
- Refinements of process. As the number, complexity, and type of information products expand, the process will need to be refined to accommodate the growth. For example, as research interface tools are developed and included with information products, they will be integrated with equally rigorous and well-defined processes to ensure integrity and utility.

REFERENCES

Moore, S., et al., (2000). *The Integration Process Design for Incorporating Information Products into the Department of Energy Knowledge Base*, SAND2000-0597.

Carr, D., et al., (2000). *Knowledge Base Contributor's Guide*, SAND2000-0442.